allows propagation along the waveguide axis of electromagnetic waves in an odd longitudinal magnetic mode, but suppresses electromagnetic waves in an even longitudinal magnetic mode.

A backplane system according to the invention comprises a substrate, such as a printed circuit board or multilayer board, with a waveguide connected thereto. The waveguide can be a non-radiative dielectric waveguide, or an air-filled rectangular waveguide. According to one aspect of the invention, the waveguide has a gap therein for preventing propagation of a lower order mode into a higher order mode.

The backplane system includes at least one transmitter connected to the waveguide for sending an electrical signal along the waveguide, and at least one receiver connected to the waveguide for accepting the electrical signal. The transmitter and the receiver can be transceivers, such as broadband microwave modems.

Another backplane system according to the invention can include a first dielectric substrate and a second dielectric substrate disposed generally parallel to and spaced from the first substrate. First and second conductive channels are disposed between the first and second substrates. The first channel is disposed along a waveguide axis. The second channel is disposed generally parallel to and spaced from the first channel to thereby define a gap between the first and second channels along the waveguide axis. The gap has a gap width that allows propagation along the waveguide axis of electromagnetic waves in TE n,0 mode, wherein n is an odd number, but suppresses electromagnetic waves in a TE m,0 mode, wherein m is an even number.

Brief Description of the Drawings

The foregoing summary, as well as the following detailed description of the preferred embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings an embodiment that is presently preferred, it being understood, however, that the invention is not limited to the specific methods and instrumentalities disclosed.

Figure 1 shows a plot of channel bandwidth vs. data channel pitch for a 0.75 m prepreg backplane.

Figure 2 shows a plot of bandwidth density vs. data channel pitch for a 0.75 m prepreg backplane.

Figure 3 shows a plot of bandwidth vs. bandwidth density/layer for a 0.5 m FR-4 backplane, and 1 m and 0.75m prepreg backplanes.

Figure 4 shows a schematic of a backplane system in accordance with the present invention.

Figure 5 depicts a closed, extruded, conducting pipe, rectangular waveguide.

Figure 6 depicts the current flows for the TE 1,0 mode in a closed, extruded, conducting pipe, rectangular waveguide.

Figure 7A depicts a split rectangular waveguide according to the present invention.

Figure 7B depicts an air-filled waveguide backplane system according to the present invention.

Figure 8 shows a plot of attenuation vs. frequency in a rectangular waveguide.

Figure 9 shows plots of the bandwidth and bandwidth density characteristics of various waveguide backplane systems.

Figure 10 provides the attenuation versus frequency characteristics of conventional laminated waveguides using various materials.

Figure 11 provides the attentuation versus frequency characteristics of a backplane system according to the present invention.

Figure 12 provides the attenuation versus frequency characteristics of another backplane system according to the present invention.

Figure 13A depicts a prior art non-radiative dielectric (NRD) waveguide.

Figure 13B shows a plot of the field patterns for the odd mode in the prior art waveguide of Figure 13A.

Figure 14 shows a dispersion plot for the TE 1,0 mode in a prior art NRD waveguide.

Figure 15A depicts an NRD waveguide backplane system.

Figure 15B depicts an NRD waveguide backplane system according to the present invention.

Figure 16 shows a plot of inter-waveguide crosstalk vs. frequency for the waveguide system of Figure 13A.

5 **Detailed Description of Preferred Embodiments**

Example of a Conventional System: Broadside Coupled Differential Pair PCB Backplane

The attenuation (A) of a broadside coupled PCB conductor pair data channel has two components: a square root of frequency (f) term due to conductor losses, and a linear term in frequency arising from dielectric losses. Thus,

10
$$A = (A_1*SQRT(f) + A_2*f)*L*(8.686 \text{ db/neper}) \quad (1)$$
where
$$A1 = (\pi*\mu_0*\rho)^{0.5} / (w/p)*p*Z_0 \quad (2)$$
and
$$A_2 = \pi*DF*(\mu_0*\varepsilon_0)^{0.5}. \quad (3)$$

15 The data channel pitch is p, w is the trace width, ρ is the resistivity of the PCB traces, and ε and DF are the permittivity and dissipation factor of the PCB dielectric, respectively. For scaling, w/p is held constant at -0.5 or less or Z_0 is held constant by making the layer spacing between traces, h, proportional to p where h/p = 0.2. The solution of Equation (1) for A = 3dB yields the 3dB bandwidth of the data channel for a specific backplane length,
20 L.

"SPEEDBOARD," which is manufactured and distributed by Gore, is an example of a low loss, prepreg (*e.g.*, "TEFLON") laminate. Figure 1 shows a plot of the bandwidth per channel for a 0.75m "SPEEDBOARD" backplane as a function of data channel pitch. As the data channel pitch, p, decreases, the channel bandwidth also
25 decreases due to increasing conductor losses relative to the dielectric losses. For a highly parallel (*i.e.*, small data channel pitch) backplane, it is desirable that the density of the